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Application of: Ghosh, et al.	Group Art Unit: 1654
Filing Date: November 3, 2003	Examiner: Flood, Michele C.
Title: A Method of Treating and/or Preventing Asthma Using Natural Compound Luteolin	Docket No. C261 1030.1 Customer No. 26158

SUBMISSION OF PRIORITY DOCUMENT(S)

Commissioner for Patents
P.O. Box 1450
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Dear Sir or Madam:

Submitted herewith is a certified copy of International Patent Application No. PCT/IN03/00072 filed March 24, 2003 to which applicant(s) claims priority.

Respectfully Submitted,

Date: September 2, 2004

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W - 5, WEST PATEL NAGAR,
NEW DELHI - 110 008.

I, the undersigned being an officer duly authorized in accordance with the provision of the Patent Act, 1970 hereby certify that annexed hereto is the true copy of the documents filed in connection with PCT Application as stated below

PCT/IN03/00072 dated 24th March 2003

Witness my hand this 5th day of August 2004.

(S.K. PANGASA)
Assistant Controller of Patents & Designs

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PCT REQUEST

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0	For receiving Office use only International Application No.	PCT 24 MARCH 2003 (24.03.03)
0-2	International Filing Date	24 MARCH 2003 (24.03.03)
0-3	Name of receiving Office and "PCT International Application"	THE PATENT OFFICE (IN/PA) PCT INTERNATIONAL APPLICATION
0-4	Form - PCT/RO/101 PCT Request	
0-4-1	Prepared using	PCT-EASY Version 2.92 (updated 01.01.2003)
0-5	Petition The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	Receiving Office (specified by the applicant)	Indian Patent Office (RO/IN)
0-7	Applicant's or agent's file reference	IN/PA-506
I	Title of invention	A METHOD OF TREATING AND/OR PREVENTING ASTHMA USING NATURAL COMPOUND LUTEOLIN
II	Applicant This person is: Applicant for Name Address:	applicant only all designated States except US COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH Rafi Marg 110 001 New Delhi India IN
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III-2	Applicant and/or inventor	
III-2-1	This person is:	
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III-2-7	State of residence	
III-3	Applicant and/or inventor	
III-3-1	This person is:	
III-3-2	Applicant for	
III-3-4	Name (LAST, First)	
III-3-5	Address:	
III-3-6	State of nationality	
III-3-7	State of residence	
IV-1	Agent or common representative; or address for correspondence The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	
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V	Designation of States	
V-1	Regional Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	AP: GH GM KE LS MW MZ SD SL SZ TZ UG ZM ZW and any other State which is a Contracting State of the Harare Protocol and of the PCT EA: AM AZ BY KG KZ MD RU TJ TM and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT EP: AT BE BG CH&LI CY CZ DE DK EE ES FI FR GB GR HU IE IT LU MC NL PT SE SI SK TR and any other State which is a Contracting State of the European Patent Convention and of the PCT OA: BF BJ CF CG CI CM GA GN GQ GW ML MR NE SN TD TG and any other State which is a member State of OAPI and a Contracting State of the PCT
V-2	National Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH&LI CN CO CR CU CZ DE DK DM DZ EC EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NI NO NZ OM PH PL PT RO RU SC SD SE SG SK SL TJ TM TN TR TT TZ UA UG US UZ VC VN YU ZA ZM ZW
V-5	Precautionary Designation Statement In addition to the designations made under items V-1, V-2 and V-3, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except any designation(s) of the State(s) indicated under item V-6 below. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit.	
V-6	Exclusion(s) from precautionary designations	NONE
VI	Priority claim	NONE
VII-1	International Searching Authority Chosen	European Patent Office (EPO) (ISA/EP)

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VIII	Declarations	Number of declarations
VIII-1	Declaration as to the identity of the inventor	-
VIII-2	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent	1
VIII-3	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application	-
VIII-4	Declaration of inventorship (only for the purposes of the designation of the United States of America)	-
VIII-5	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty	-

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VIII-2-1	Declaration: Entitlement to apply for and be granted a patent Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent (Rules 4.17(ii) and 51bis.1(a)(ii)), in a case where the declaration under Rule 4.17(iv) is not appropriate: Name:	in relation to this international application COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH is entitled to apply for and be granted a patent by virtue of the following:
VIII-2-1 (i)		GHOSH, Balaram of Mall Road Delhi India is the inventor of the subject matter for which protection is sought by way of this international application
VIII-2-1 (iv)		an assignment from GHOSH, Balaram to COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, dated 22 March 2003 (22.03.2003)
VIII-2-1 (i)		DAS, Moumita of Mall Road Delhi India is the inventor of the subject matter for which protection is sought by way of this international application
VIII-2-1 (iv)		an assignment from DAS, Moumita to COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, dated 22 March 2003 (22.03.2003)
VIII-2-1 (i)		RAM, Arjun of Mall Road Delhi India is the inventor of the subject matter for which protection is sought by way of this international application
VIII-2-1 (iv)		an assignment from RAM, Arjun to COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, dated 22 March 2003 (22.03.2003)
VIII-2-1 (ix)	This declaration is made for the purposes of:	all designations except the designation of the United States of America

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IX	Check list	number of sheets	electronic file(s) attached
IX-1	Request (including declaration sheets)	6	-
IX-2	Description	10	-
IX-3	Claims	1	-
IX-4	Abstract	1	EZABSTOO .TXT
IX-5	Drawings	5	-
IX-7	TOTAL	23	
IX-8	Accompanying items	paper document(s) attached	electronic file(s) attached
IX-17	Fee calculation sheet	✓	-
IX-17	PCT-EASY diskette	-	Diskette
IX-19	Figure of the drawings which should accompany the abstract	NIL	
IX-20	Language of filing of the international application	English	
X-1	Signature of applicant, agent or common representative		
X-1-1	Name (LAST, First)	BHOLIA, Ravi [IN/PA-506]	

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10-1	Date of actual receipt of the purported international application	24 MARCH 2003 (24.03.03)
10-2	Drawings:	
10-2-1	Received	Yes
10-2-2	Not received	
10-3	Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application	
10-4	Date of timely receipt of the required corrections under PCT Article 11(2)	
10-5	International Searching Authority	ISA/EP
10-6	Transmittal of search copy delayed until search fee is paid	

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11-1	Date of receipt of the record copy by the International Bureau	
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PCT (ANNEX - FEE CALCULATION SHEET)

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(This sheet is not part of and does not count as a sheet of the international application)

0	For receiving Office use only			
0-1	International Application No.	72		
0-2	Date stamp of the receiving Office	CH 2003 (22.03.2003)		
0-4	Form - PCT/RO/101 (Annex) PCT Fee Calculation Sheet Prepared using	PCT-EASY Version 2.92 (updated 01.01.2003)		
0-9	Applicant's or agent's file reference	IN/PA-506		
2	Applicant	COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, et al.		
12	Calculation of prescribed fees	fee amount/multiplier	Total amounts (USD)	Total amounts (INR)
12-1	Transmittal fee	T	⇒	0
12-2-1	Search fee	S	⇒	936
12-2-2	International search to be carried out by	EP		
12-3	International fee Basic fee (first 30 sheets)	b1	407 USD	
12-4	Remaining sheets		0	
12-5	Additional amount	(X)	9 USD	
12-6	Total additional amount	b2	0 USD	
12-7	b1 + b2 =	B	407 USD	
12-8	Designation fees Number of designations contained in international application		95	
12-9	Number of designation fees payable (maximum 5)		5	
12-10	Amount of designation fee	(X)	88 USD	
12-11	Total designation fees	D	440 USD	
12-12	PCT-EASY fee reduction	R	-125 USD	
12-13	Total International fee (B+D-R)	I	⇒	722
12-17	TOTAL FEES PAYABLE (T+S+I+P)		⇒	1,658
12-19	Mode of payment	bank draft		

VALIDATION LOG AND REMARKS

13-2-4	Validation messages Priority	Green? No priority of an earlier application has been claimed. Please verify
13-2-7	Validation messages Contents	Yellow! The power of attorney or a copy of the general power of attorney will need to be furnished unless all applicants sign the request form.

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A METHOD OF TREATING AND/OR PREVENTING ASTHMA USING NATURAL COMPOUND LUTEOLIN

Field of the present invention

5 The present invention relates to a method of preventing and/or treating asthma in animals including humans using natural compound Luteolin, said method comprising administering therapeutically effective dose of the Luteolin and leading to level of IFN-gamma increasing to normal level, levels of IL-5, IL-4, and IgE decreasing to normal level, and further, said method inhibits airway constriction, and airway hyperreactivity.

10 Background of the present invention

Luteolin is a naturally occurring flavonoid, which has been attributed with anti-inflammatory (Mann et al., 1984; Xagorari et al., 2001) and anti-allergic properties (Mann et al., 1984). *In vitro* studies have elucidated some of the molecular mechanisms by which Luteolin modulates the inflammatory response. Luteolin has been reported to inhibit: a) the 15 release of mediators like leukotrienes and prostaglandin's (Xagorari et al., 2001), b) the production of the proinflammatory cytokine, IL-5 (Park et al., 1999) and c) the process of signal transduction leading to the inhibition of nuclear transcription factor-kappa B (NF-KB mediated gene expression (Xagorari et al., 2001). In addition, Luteolin suppresses the expression of TNF-gamma induced ICAM molecules on endothelial cells (Shimoji et al., 2000). Based on these evidences, we postulated that Luteolin might have a preventive 20 and/or therapeutic role in attenuating asthma.

Asthma is an inflammatory disease of the airways and is characterized by difficulty in breathing due to constriction of smooth muscles of the bronchi as a result of inflammation. The development of the disease is mediated by cytokines- IL-4, IL-5, IgE, eosinophils and 25 various mediators, e.g. histamine, leukotrienes and others (Abbas et al., 1994; Weiss et al., 1993) all of which lead to the symptoms of asthma. On the other hand, IFN-gamma inhibits this process (Barnes, 2000).

The current focus in managing asthma is the control of inflammation using anti-asthmatic drugs with lower or negligible side effects (Barnes, 1999). Search is going on for novel 30 drugs, especially of natural origin, as they may have negligible side effects.

Keeping in view of the above properties, we examined Luteolin for its anti-asthmatic activity using a mouse model of asthma. Till date there is no direct *in-vivo* experiment which demonstrated the effect of Luteolin on asthmatic features either in human or animal model. Novelty of the invention is in first *in-vivo* demonstration of Luteolin for alleviation

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the characteristic features of asthma produced in mouse such as allergen-induced early airway response (EAR) and late airway response (LAR).

Objects of the present invention

The main object of the present invention is to develop a method of preventing and/or treating asthma in animals including humans using natural compound Luteolin.

Another main object of the present invention is to develop a method of treating asthma wherein, the compound Luteolin shows no side effects.

Another main object of the present invention is to develop a method of treating asthma wherein, the compound Luteolin is administered orally.

10 Yet another main object of the present invention is to develop a method of treating asthma using compound Luteolin wherein, the development of asthmatic features comprising Early Airway Response (EAR) and Late Airway Response (LAR) are prevented.

Still another main object of the present invention is to develop a method of treating asthma using compound Luteolin wherein, level of IFN-gamma increases to normal level.

15 Still another main object of the present invention is to develop a method of treating asthma using compound Luteolin wherein, level of IL-5 decreases to normal level.

Still another main object of the present invention is to develop a method of treating asthma using compound Luteolin wherein, level of IL-4 decreases to normal level.

20 Still another main object of the present invention is to develop a method of treating asthma using compound Luteolin wherein, level of IgE decreases to normal level.

Still another main object of the present invention is to develop a method of treating asthma using compound Luteolin wherein, compound Luteolin inhibits airway constriction.

Still another main object of the present invention is to develop a method of treating asthma using compound Luteolin wherein, compound Luteolin inhibits airway hyperactivity.

Summary of the present invention

The present invention relates to a method of preventing and/or treating asthma in animals including humans using natural compound Luteolin, said method comprising administering therapeutically effective dose of the Luteolin and leading to level of IFN-gamma increasing to normal level, levels of IL-5, IL-4, and IgE decreasing to normal level, and further, said method inhibits airway constriction, and airway hyperreactivity.

Detailed description of the present invention

Accordingly, the present invention relates to a method of preventing and/or treating asthma in animals including humans using natural compound Luteolin, said method comprising

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administering therapeutically effective dose of the Luteolin and leading to level of IFN-gamma increasing to normal level, levels of IL-5, IL-4, and IgE decreasing to normal level, and further, said method inhibits airway constriction, and airway hyperreactivity.

In an embodiment of the present invention, a method of preventing and/or treating asthma

- 5 in animals including humans using natural compound Luteolin, said method comprising administering therapeutically effective dose of the Luteolin.

In another embodiment of the present invention, wherein the compound Luteolin shows no side effects.

- 10 In yet another embodiment of the present invention, wherein the compound Luteolin is administered orally.

In still another embodiment of the present invention, wherein the development of asthmatic features comprising Early Airway Response (EAR) and Late Airway Response (LAR) are prevented.

- 15 In still another embodiment of the present invention, wherein level of IFN-gamma increases to normal level.

In still another embodiment of the present invention, wherein level of IL-5 decreases to normal level.

In still another embodiment of the present invention, wherein level of IL-4 decreases to normal level.

- 20 In still another embodiment of the present invention, wherein level of IgE decreases to normal level.

In still another embodiment of the present invention, wherein the concentration of compound Luteolin is ranging between 0.1 to 10 mg/kg body weights.

- 25 In still another embodiment of the present invention, wherein the concentration of compound Luteolin is ranging between 1 mg/kg body weights.

In still another embodiment of the present invention, wherein the duration of administering compound Luteolin is ranging between 5 to 10 days.

In still another embodiment of the present invention, wherein compound Luteolin inhibits airway constriction.

- 30 In still another embodiment of the present invention, wherein compound Luteolin inhibits airway hyperactivity.

Brief description of accompanying drawing

Figure 1 shows structure of Luteolin

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Figure 2 shows the protocol for the sensitization and Luteolin treatment to mice. Protocol A : The mice were given three i.p. Injections of 10 µg ovalbumin adsorbed on 2 mg alum on 0, 7 and 14 days and then subjected to OVA aerosol inhalation for five consecutive days from 19th to 23rd day of the experiment. On 24th day SGaw measurements were performed

5 after OVA challenge in the plethysmograph and airway reactivity to methacholine was measured after 24 hours. In case of curative study (Protocol B), sensitized mice were fed with 1 mg/kg body weight of Luteolin for one week (days 26-32) and the effects on SGaw and airway reactivity were evaluated.

10 **Figure 3 shows** the effect of Luteolin during and after sensitization period on specific airway conductance, SGaw. Mice were fed with Luteolin for a period of 23 days during sensitization and for one week after sensitization. SGaw levels were measured before and after OVA aerosol challenge. * indicates significant difference from the sensitized group.

15 **Figure 4 shows** the effect of feeding Luteolin during sensitization period on the development of airway hyperreactivity. Mice were fed with Luteolin during and after sensitization period and airway reactivity (MCh PD₃₅) was measured as described in Example 5. * indicates significant difference from the sensitized group.

20 **Figure 5 shows** the effect of oral Luteolin treatment on OVA-specific IgE levels in serum of mice. * indicates significant difference from the sensitized group.

In still another embodiment of the present invention, wherein the existing anti-asthmatic drugs, particularly steroids, have many side effects. There is intense need to develop certain non-steroidal anti-asthmatic drugs preferably of natural origin. In this context, Luteolin (Figure 1), a plant based natural non-steroidal anti-inflammatory compound, was 25 tested for the anti-asthmatic activity using mouse model of asthma.

In still another embodiment of the present invention, wherein administration of pharmacologically effective dose of Luteolin to mice during sensitization prevented the development of both the asthmatic features (EAR and LAR). This finding showed a preventive effect of Luteolin on the development of asthma.

30 The present invention also showed that Luteolin, when administered orally to the animals already showing impaired airways features, alleviated the existing impaired features. Luteolin has been found to increase IFN- α levels and attenuated IL-5 levels in the bronchoalveolar lavage (BAL) fluid. The allergen-specific IgE levels in the sera samples were also reduced significantly.

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In still another embodiment of the present invention, wherein accordingly, present invention relates to novel use of Luteolin as an anti-asthmatic agent and the method of use comprises of:

- a. sensitizing the animals by an antigenic protein to induce characteristic asthmatic features,
- b. estimating asthmatic features prior to, during and after sensitization of the animals,
- c. Administering pharmacologically active concentration of a solution of Luteolin to healthy animals during and after sensitization,
- d. measuring immunological features in the sacrificed animals after step (b) and (c).

5 10 In still another embodiment of the present invention, wherein the animal model used may be selected from BALB/c mice, rabbits and guinea pigs.

In another embodiment to the invention the protein for sensitizing the animals may be administered through intraperitoneally injection or aerosol inhalation routes.

15 In yet another embodiment to the invention, the protein solution in normal saline used for sensitization may be selected from ovalbumin, bovine serum albumin or any other antigenic protein, in a concentration ranging from 10-100 µg per injection or 1-5% for inhalation by aerosol in normal saline.

In still another embodiment to the invention, luteolin may be administered orally to the animals in the concentration range of 0.1 to 10 mg/kg body weight.

20 25 In yet another embodiment, the asthmatic features may be estimated by known methods of measuring specific airway conductance or specific airway resistance.

In still another embodiment to the invention the immunological features may be measured by estimating IgE, IFN- γ , IL-4 and IL-5 levels by known methods.

30 In still another embodiment of the present invention, wherein asthma is an inflammatory disease of the airways, which affects millions of people worldwide. The disease is reaching epidemic proportions and young lives are increasingly rendered unproductive. Asthma is characterized by difficulty in breathing due to constriction of smooth muscles of the bronchi as a result of inflammation. It is characterized by elevated levels of immunoglobulin E in the blood and infiltration of eosinophils into the airways. The development of the disease is mediated by cytokines- IL-4 and IL-5, IgE, eosinophils and various other mediators e.g. leukotrienes, cyclooxygenase products, phospholipases all of which lead to the symptoms of asthma (Abbas et. al., 1994, Weiss et. al., 1993). In contrast, IFN- \square inhibits this process (Barnes, 2000).

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The current focus in managing asthma is to control inflammation using anti-asthmatic drugs with low side effects (Barnes, 1999). There is a need for novel drugs for the treatment of asthma, which may have fewer side effects.

In this context, Luteolin was tested on mouse model of asthma. Mice were sensitized with

5 intraperitoneal and aerosol inhalation of OVA to develop the characteristic features of asthma such as allergen induced early airway response (EAR) and late airway response (LAR). These asthmatic features were characterized by measuring airway calibre in the term of specific airway conductance (SGaw) by a non-invasive technique, dual-chamber whole body plethysmography. After developing the characteristic features (EAR and LAR)
10 in mouse, the compound, Luteolin was given orally during whole sensitization period to test the preventive effect on the development of asthmatic features. To examine the therapeutic effect of Luteolin on the asthmatic features, it was fed for one week to mice after sensitization and confirming their asthmatic features.

15 After testing the compound for the preventive as well as for therapeutic effects in intact conscious mice, mice were sacrificed for collecting the blood and bronchoalveolar lavage (BAL) fluid to measure the levels of IgE, cytokines IL-4, IL-5 and IFN- γ . Ovalbumin specific IgE levels in the sera and the levels of IL-4, IL-5 and IFN- γ in the BAL fluid were measured by enzyme linked ImmunoSorbent assay (ELISA) kits.

20 In still another embodiment of the present invention, wherein the present invention provides an effective compound for preventing the development of the characteristic features of asthma in an animal. For example, there was prevention of the development of airway constriction and airway reactivity in mice treated orally with Luteolin during sensitization.

25 In still another embodiment of the present invention, wherein the present invention also demonstrates that Luteolin is effective when given to mice after sensitization i.e., after developing airway hyperactivity. Luteolin administered orally for one week to airway hyperactive animals, inhibited both allergen induced airway constriction and airway hyper reactivity to methacholine. This showed the therapeutic potential of this compound.

30 The present invention also showed that Luteolin reduces IgE in the serum and IL-5 in the BAL fluid, which is favorable for improving the impaired airways features (EAR and LAR).

Luteolin administration to the mice both during sensitization as well as after sensitization, increased significantly the levels of IFN-gamma in the BAL fluid. This finding suggests that Luteolin inhibits inflammation by administering its pharmacologically effective dose.

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The effective dose was found to be 1mg/kg body weight.

Table I. Luteolin up regulates IFN-gamma levels and decreases IL-5 levels in the BALF.

Treatment	IFN- γ (pg/ml)	IL-4 (pg/ml)	IFN- γ : IL-4	IL-5 (pg/ml)
Sham-sensitized	2650 ± 50	130 ± 10	9.2 ± 5.1	118 ± 19
Sensitized	81 ± 3.8	171 ± 23.8	0.5 ± 1.0	149 ± 3.5
Luteolin (0.1 mg/kg) ^a	3533 ± 427**	136 ± 4.0	26 ± 2.7**	73 ± 13.4*
Luteolin (1.0 mg/kg) ^a	2652 ± 114.3**	169 ± 13.9	16 ± 1.3**	43 ± 3.5*
Luteolin (10.0 mg/kg) ^a	1247 ± 412.5**	128 ± 8.8	13 ± 2.5**	235 ± 66.4
Luteolin (1.0 mg/kg) ^b	2067 ± 233.3**	130 ± 5.0	16 ± 2.2**	44 ± 2.3*

5 Experiments were performed with six groups of mice (n=6) as described in Figure 3 legend and the levels of IFN- γ , IL-4 and IL-5 were measured in the BALF. The values are a mean ± SEM of six mice in each group. Mann Whitney U test was used to determine the significant differences between the sensitized- and Luteolin treated groups. * p < 0.05, ** p<0.01 . ‘a’ denotes treatment during sensitization; ‘b’ denotes treatment after 10 sensitization.

The following examples are given for the purpose of illustrating various embodiments of the inventions and are not meant to limit the present invention in any fashion.

EXAMPLE 1

15 **Animals' sensitization:**

Mice were immunized/sensitized with or without (sham-sensitized) 0.2 ml of 10 µg ovalbumin (Sigma Chemicals Co. St Louis, MO, USA) and 2 mg aluminum hydroxide intraperitoneally on days 0,7 and 14 using a modified protocol previously described by Sakai *et al* (Figure 2). Five days after the final i.p injection, the mice were subjected to 20 aerosolized OVA (5%) or phosphate buffered saline (PBS) (for sham-sensitized group) inhalation for 20 minutes daily beginning from day 19 to day 23 (Figure-2). Mice were placed in a plexiglas chamber (20 x 20 x 20cm dimensions) and exposed to an aerosol generated from a nebulizer (de Vilbiss, USA) with airflow of 4l/min.

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EXAMPLE 2**Treatment of mice with Luteolin:**

To study the preventive effect, Luteolin (dissolved in 50% hydro-alcohol) (Sigma Chemicals Co. St Louis, MO, USA) (0.1, 1.0, and 10.0 mg/kg body weight, 20 µl volume) or vehicle (i.e., 50% hydro-alcohol) was administered orally to each group of mice daily, starting from the first day of sensitization (Fig 2A). To study the curative effect, mice were first sensitized as described before (*Example 1*) followed by oral Luteolin (1.0 mg/kg body weight) treatment daily from day 26 to 32 (Fig 2B).

EXAMPLE 3**10 Measurement of airways calibre:**

Airway calibre was measured in the term of specific airway conductance (SGaw) using a dual-chamber whole body plethysmograph similar to the method for guinea pigs (Agrawal, 1981) with some modifications. The dual-chamber whole body plethysmograph was designed in our laboratory to suit the size of mouse. The value of SGaw was calculated as described by Agrawal (1981).

15 EXAMPLE 4**Luteolin inhibits acute OVA-induced airway constriction:**

Airway constriction of mice was determined in terms of fall of SGaw due to OVA aerosol challenge. SGaw was measured as described in *Example 3*. To determine the preventive effect of Luteolin, mice were dosed with Luteolin (0.1, 1.0 and 10.0 mg/kg body weight) or vehicle during sensitization, as described in the *Example 2*. Following challenge, OVA-sensitized mice treated with vehicle showed a 43% fall in specific airway conductance (SGaw) as compared to their basal values, whereas sham- sensitized mice showed no change (Fig 3). Interestingly, treatment with Luteolin markedly prevented OVA-induced decrease in SGaw. The dose of 0.1 mg/kg Luteolin markedly reduced the fall in SGaw induced by OVA and only a 7% decrease was recorded ($p<0.01$). Further increase of the doses did not show any greater reduction in OVA-induced decreases in SGaw ($p<0.01$). To examine the curative effect of Luteolin, mice were first sensitized and then treated with Luteolin (1.0 mg/kg) for one week (*Example 2*). Luteolin was found to reverse OVA-induced decrease in SGaw (Fig3).

30 EXAMPLE 5:**Luteolin reduces airway reactivity to methacholine (MCh):**

Airway reactivity to methacholine was determined by measuring the concentration of inhaled methacholine that produced 35% fall in SGaw (MCh PD₃₅) in intact mouse sitting

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in the body plethysmograph. Aerosol of different concentrations of methacholine (3.1, 6.25, 12.5, 50, 100 mg/ml) were given for 60 seconds. MCh PD₃₅ values were determined in sham-sensitized, sensitized and Luteolin treated mice during and after sensitization. As shown in Figure 4, there was a significant fall in MCh PD₃₅ values (1.3 ± 0.5 mg/ml PBS) following OVA challenge in sensitized mice compared to normal mice (97 ± 1.0 mg/ml, p<0.01). Treatment with Luteolin (0.1, 1.0 and 10.0 mg/kg during sensitization) markedly attenuated the development of airway hyperreactivity to methacholine. MCh PD₃₅ values increased following Luteolin treatment to 72.1 ± 1.9 , 42.4 ± 4.2 and 10.9 ± 4.8 mg/ml, respectively (p<0.01). In addition, when the mice were first sensitized and then treated with Luteolin (1.0 mg/kg) for one week, MCh PD₃₅ values increased significantly (p<0.01) suggesting that Luteolin inhibited the development of OVA-induced airway hyperreactivity.

EXAMPLE 6:**Luteolin treatment during and after sensitization reduces serum IgE levels.**

OVA-specific IgE levels in the serum were measured by enzyme linked ImmunoSorbent assay (ELISA). To investigate the effect of Luteolin on serum IgE levels, we compared the levels of the OVA-specific IgE in serum of mice treated with vehicle or with Luteolin (0.1, 1.0 and 10.0 mg/kg) during sensitization and in sham-sensitized mice. As shown in Figure 5, the IgE values increased in sensitized mice when compared to sham-sensitized mice (3.3 ± 0.4 versus 0.24 ± 0.07 ; p < 0.05). Luteolin was found to decrease the serum IgE levels in sensitized mice when compared with vehicle treated sensitized group (0.74 ± 0.4 , 0.93 ± 0.03 , 0.97 ± 0.07 following doses of 0.1, 1.0 and 10.0 mg/kg respectively versus 3.3 ± 0.4 in sensitized, vehicle treated mice; p < 0.05). When serum IgE levels in mice, first sensitized and then treated with Luteolin (1.0 mg/kg) for a week, were measured, the IgE level was found to be decreased (2.07 ± 1) as compared to sensitized mice (p < 0.05)..

EXAMPLE 7:**Luteolin increases the ratio of IFN-γ to IL-4 and decreases IL-5 in the BAL fluid.**

To investigate the levels of IL-4 and IFN- \square in the BALF, we measured the cytokine levels by ELISA as per manufacturer's protocol, and compared between the different groups. As shown in Table 1, serum levels of IFN-γ were significantly elevated in OVA-sensitized mice treated with Luteolin, whereas in the untreated OVA-sensitized mice, IgE levels were reduced. In the Luteolin-treated group, there was an increase in the ratio of IFN-γ/IL-4 (25.8 ± 2.7 , 15.5 ± 1.3 , 13.2 ± 2.5 following doses of 0.1, 1.0 and 10.0 mg/kg Luteolin,

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respectively as compared to 0.48 ± 0.1 in sensitized, vehicle treated mice) ($p<0.01$) (Table 1). In the mice first sensitized and then treated with Luteolin (1.0 mg/kg) for one week, the ratio of IFN- γ /IL-4 was also increased (16 ± 2.2) ($p<0.01$) as compared to sensitized, vehicle treated mice. This increase in the IFN- γ /IL-4 ratio was due to the increase in the 5 IFN- γ levels. We also measured the concentration of IL-5 in the BALF by ELISA in the different groups (Table 1). In the Luteolin-treated group, a decrease in the levels of IL-5 was seen (73.3 ± 13.4 and 43.3 ± 3.5 following doses of 0.1 and 1.0 mg/kg Luteolin respectively as compared to 148.5 ± 3.5 in sensitized, vehicle treated mice)(Table 1). In the sensitized mice treated with Luteolin (1.0 mg/kg) for one week, the IL-5 level was 10 decreased (43.7 ± 2.3) as compared to sensitized, vehicle treated mice.

Advantages of the present invention

1. This is the first demonstration that Luteolin inhibits the characteristic features of asthma produced in an animal model and can be used for development of effective drugs for asthma therapy.
- 15 2. Luteolin, being a plant based natural non-steroidal compound, may have lesser side effects than the existing therapeutic steroids.
3. This compound is readily available.
4. The use of Luteolin may not be restricted only to anti-asthmatic agent, but to other inflammatory conditions where elevations of IgE and IL-5, and reduction in IFN-gamma levels play significant roles.

Claims

1. A method of preventing and/or treating asthma in animals including humans using natural compound Luteolin, said method comprising administering therapeutically effective dose of the Luteolin.
- 5 2. A method as claimed in claim 1, wherein the compound Luteolin shows no side effects.
3. A method as claimed in claim 1, wherein the compound Luteolin is administered orally.
- 10 4. A method as claimed in claim 1, wherein the development of asthmatic features comprising Early Airway Response (EAR) and Late Airway Response (LAR) are prevented.
5. A method as claimed in claim 1, wherein level of IFN-gamma increases to normal level.
- 15 6. A method as claimed in claim 1, wherein level of IL-5 decreases to normal level.
7. A method as claimed in claim 1, wherein level of IL-4 decreases to normal level.
8. A method as claimed in claim 1, wherein level of IgE decreases to normal level.
9. A method as claimed in claim 1, wherein the concentration of compound Luteolin is ranging between 0.1 to 10 mg/kg body weights.
10. A method as claimed in claim 1, wherein the concentration of compound Luteolin is ranging between 1 mg/kg body weights.
- 20 11. A method as claimed in claim 1, wherein the duration of administering compound Luteolin is ranging between 5 to 10 days.
12. A method as claimed in claim 1, wherein compound Luteolin inhibits airway constriction.
- 25 13. A method as claimed in claim 1, wherein compound Luteolin inhibits airway hyperactivity.

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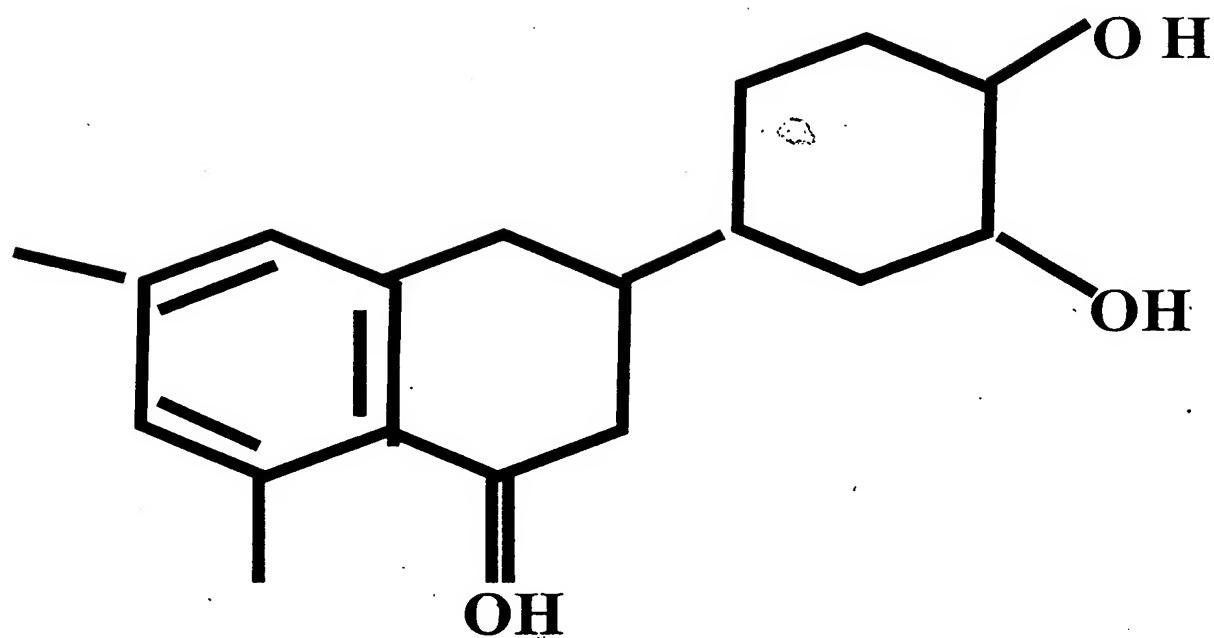
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Abstract

The present invention relates to a method of preventing and/or treating asthma in animals including humans using natural compound Luteolin, said method comprising administering therapeutically effective dose of the Luteolin and leading to level of IFN-gamma increasing to normal level, levels of IL-5, IL-4, and IgE decreasing to normal level, and further, said method inhibits airway constriction, and airway hyperreactivity.

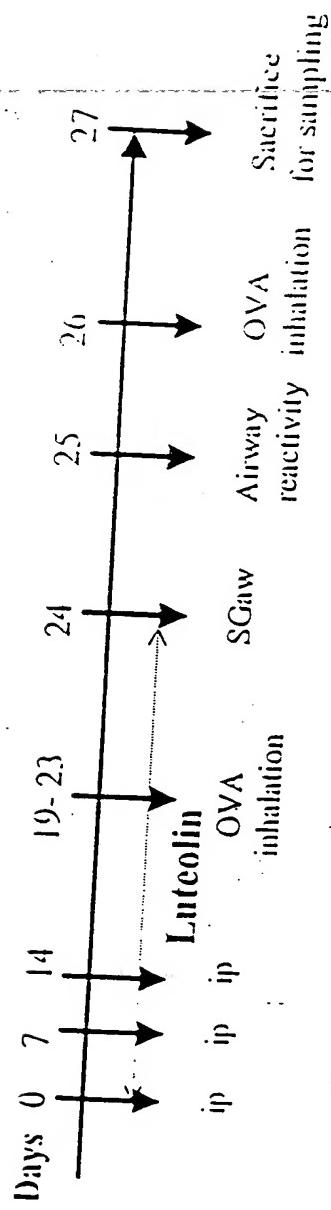
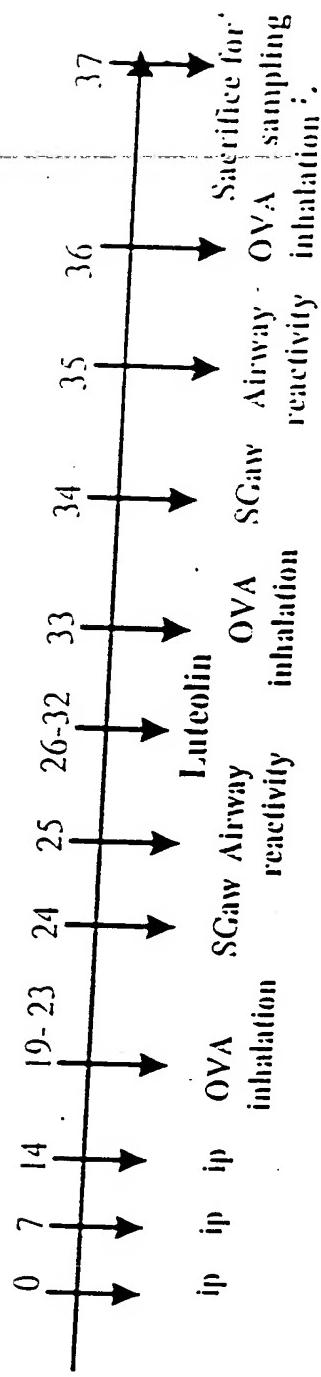
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**FIGURE 1**

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A: Protocol for the preventive effect of Luteolin**B: Protocol for the curative effect of Luteolin****Figure 1**

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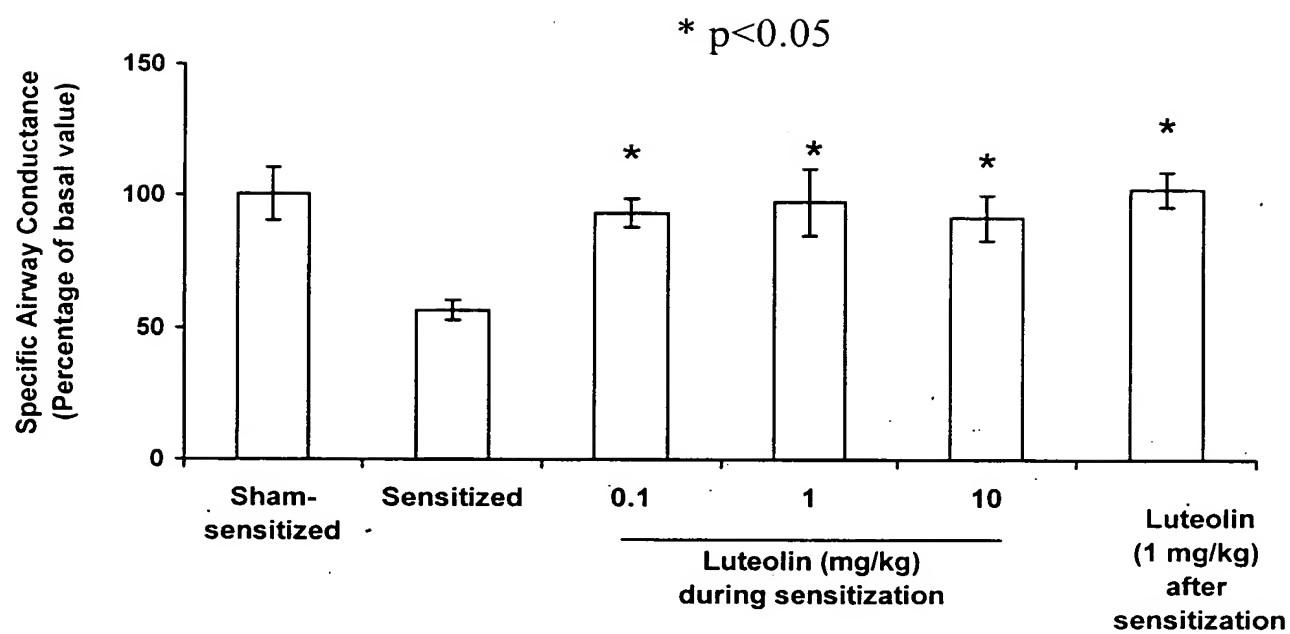


Figure 3

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* p<0.05, ** p<0.01

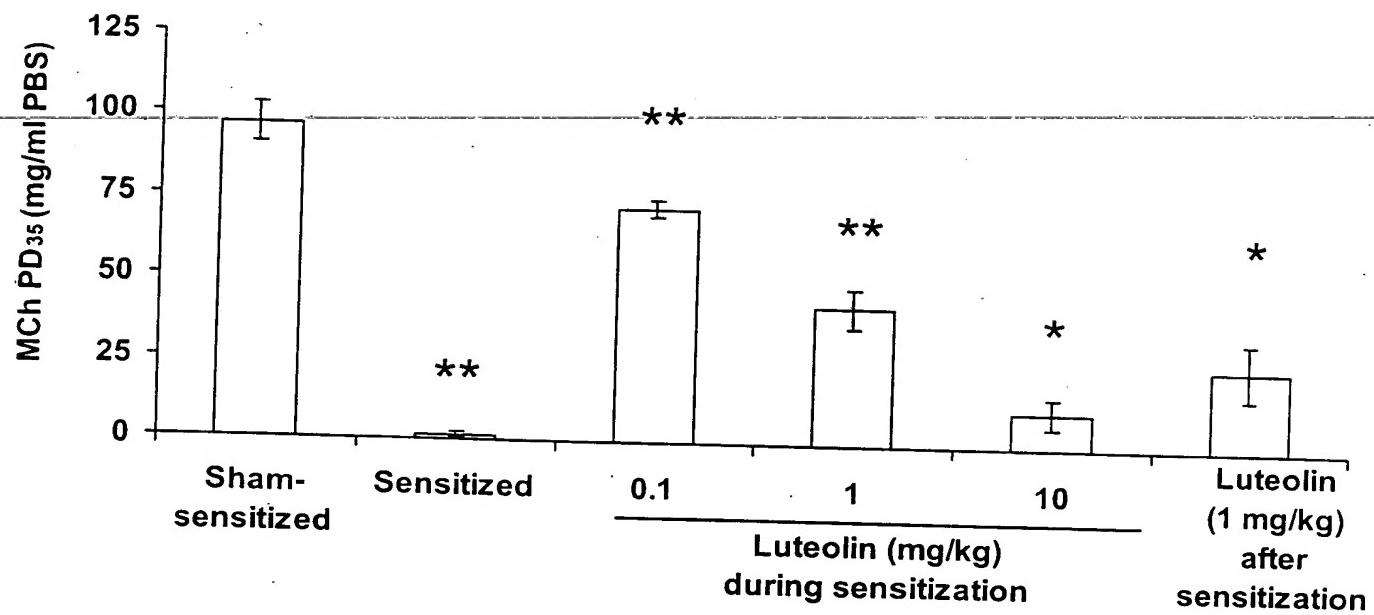


Figure 4

* p<0.05, ** p<0.01

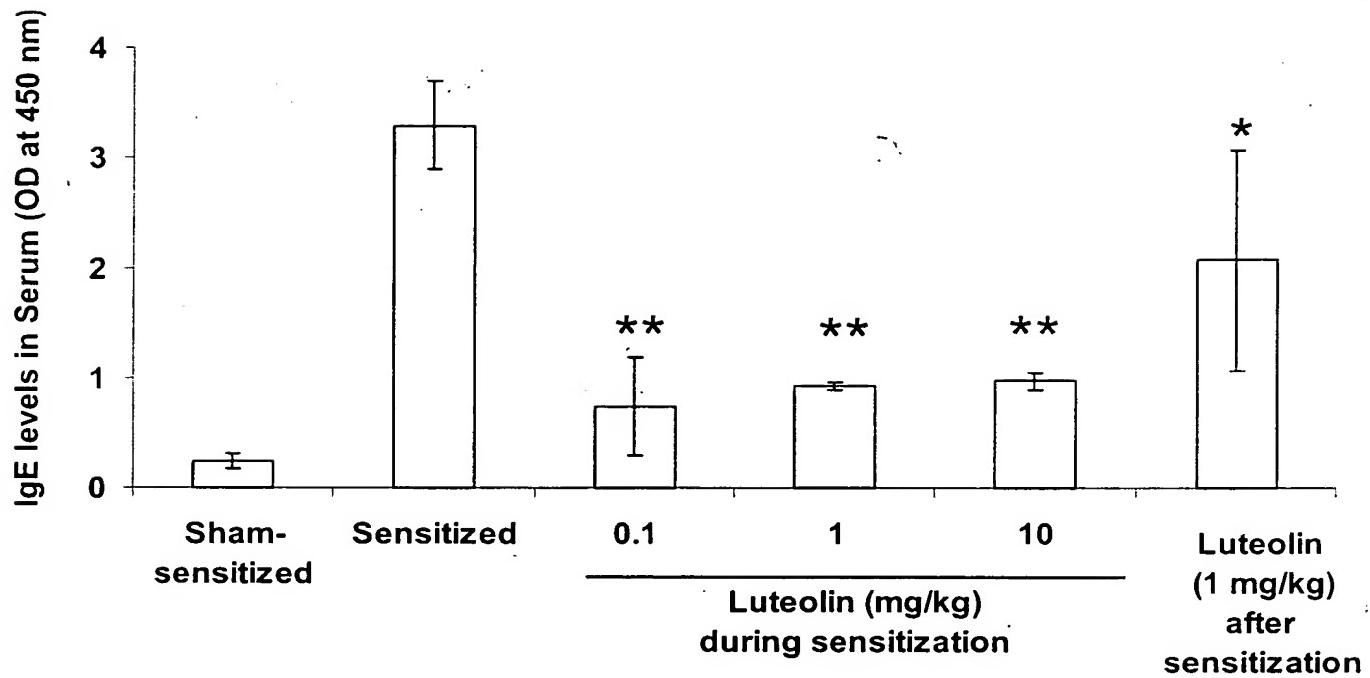


Figure 5

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